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Analysis of Land Use Change in the Period of 2001-2016 Using Remote Sensing Technique in Watershed Bila in South Sulawesi Province, Indonesia

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Abstract

Land use that is incompatible to its carrying capacity and watershed capacity causes land use change/land cover. This study aims to analyze the changes of land use/land cover in the watersheds to obtain a spatial description of land use changes/land cover that had been occurred in the last fifteen years in watershed Bila in South Sulawesi Province. This mapping-based research belongs to non-experimental research using survey method. The determination of the coordinates of the representative points shall be carried out purposively based on the accessibility of the land units. Data were analyzed spatially. Land use change/land cover was calculated using method of land change matrix. The results showed that land use change/land cover in the period of 2001-2016 for primary dryland forest was declined and changed into secondary dry forest (1701,16 ha) and bush (92.22 ha). Land cover of dry secondary forest was increased from bushes (516.23 ha), open land (5.34 ha) and dry primary forest (1701,16 ha). Land use was increased from swamp forest (97.87 ha), mixed dryland agriculture (121.67 ha) and rice field (514.97 ha). Furthermore, use of mixed-shrub dry land farm decreased and changed into settlements (121.67 ha) and rice fields (742.49 ha).

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For wetland use, the increase of the extent of Dryland Farms (742.49 ha) and marshlands (254.78 ha) occurred. The land cover of shrubland experienced a change into primary dryland forest (92.22 ha) and Secondary Dryland (516.23 ha). Thus, Land use in the watershed area requires integrated land use planning to maintain balance between ecological function and economic function so that the sustainability of the watershed can be preserved.

Keywords: land use change; remote sensing; watersheds.

1. Introduction

Utilization of natural resources, especially natural forest resources in the watersheds is very important and useful for life, directly and indirectly. The immediate benefits of forest existence include timber, non-timber forest products and wildlife. Whereas the indirect advantages are environmental services, aesthetic functions, and as a watershed regulator or as a provider of oxygen and carbon sink. Most of Watersheds in Indonesia are in critical condition which is reflected from frequent occurrence of floods and droughts, as well as landslides and the spread of degraded lands. Decree of Minister of Forestry No. SK.328 /Menhut-II/2009 mentioned that as many as 108 watersheds, include catchment basin Bila, are in critical condition that requires immediate treatment. The area of critical land within the river basin is an indication of the criticality level of a watershed and one of the indicator of the criticality of land is the change of land use. Currently, the purposes of land use in watershed Bila are for forests, paddy fields, plantations, pastures, shrubs and others purposes that have impacts on the sustainability of the catchment basin. In general, land cover of watershed Bila in 2010 was dominated by Dryland Farm which extend 69,665 ha or 38.79%, 29,133 ha or 16.22% of rice fields and 21,874 ha or 12.18% of shrubs. Meanwhile, cover of primary forests was 30,938 ha or 17.23% and 10,405 ha or 5.79% of secondary forests. It means that only 41.344 ha or 23.02% of the total area of the watershed covered by forests. In the same year, the level of critical land that occurred from upstream to downstream in the Bila catchment area was classified into critical potential condition with an area of 72.585 ha or 40.41%, rather critical area of 69.150 ha or 38.50%, critical area of 8.609 ha or 4.79% , Very critical area of 2704.55 ha or 1.51% and uncritically land conditions only cover 22.574 ha or 12.57% of the total area of the watershed Bila [1]. The above conditions are due to forest encroachment, illegal logging, shifting cultivation, exploitation of non-eco-friendly forest products and incompatible land use to watershed capacity, which was resulting in land use change and triggered the increase of critical land. Based on the above description, it is necessary to conduct a study on change of land use/land cover in the watershed Bila to obtain a spatial picture of land use changes during the last 15 years in the watershed Bila in Province of South Sulawesi.

2. Materials and Methods

2.1. Time and Studies Site

This research was conducted in May to July, 2016. The research location was in watershed Bila, South Sulawesi Province (Figure 1).

2.2. Data Collection Procedures

The procedures of data completion begin with spatial classification of Landsat 7 ETM+ satellite imagery and satellite locations in 2001 and Landsat 8 ETM+ satellite image interpretation of 2016 to create the latest landfill/land use map. Determination of the point coordinates that are the representatives of any land cover/land use was based on the ease of accessibility of the land cover/land use. Observation activities are carried out on every predetermined point by checking and verify the result of image interpretation data with land closure/land use condition` using accuracy table of image overlay.

2.3. Methods of Data Analysis

Delineation method was used to analyse the data of image interpretation. The land view classes was based on the pattern and characteristics (hues, colors, and textures) on the image. To facilitate the analysis, a spatial approach was made using the levels developed by T.C. Whitmore [2]. Accuracy test of image classification was used to investigate the precision of the interpretation of the images that we have done. This process is called *overall accuracy* with the following equation:

$$\text{Overall Accuracy (OA)} = \frac{X}{N} \times 100\%$$

Where: X = total values of matrix diagonal

N = the amount of sample matrix

Acceptable level of accuracy of images interpretation is 85% [3], which means at least 85 out of 100 specified sample points have to match the field condition. Moreover, the purpose of a map overlay is to attain information about land use changes. The results from overlay of spatial data are map data dan tabular data which present a combination of land use changes. Additionally, matrix of land changes was used to analyze transformation of land cover/land use on two different time, that was the year of 2001 and 2016. This method is able to examine the alternation of each class of land cover/land use and confirm the extension of the transformation.

3. Results

The results in Table 1 presented that the area of Watershed was 179,612.95 ha and its land use / land cover was distinguished into 11 classes, which are swamps, primary forests, secondary forests, settlements, dryland farming, mixed-shrub dryland Farming, savanna, rice fields, shrubs, open land, and water bodies. What's more, the condition of land use/land cover of watershed Bila in 2001(Figure 2) was dominated by mixed-shrub dryland agriculture with the area of 70,006.94 ha or 38.98%. However, in 2016(Figure 3) the area of this type of land use was decreased as much as 864.16 ha to 69,142.78 ha or 38.50% of the area of the river basins. It was likewise the land cover of primary forests in the same period which was decline as much as 1,793.38 ha from 32,734,88 ha (18.23%) in 2001 to 30,941.49 ha (17.23%) in 2016. On the contrary, land use for paddy fields in these periods was ascended 482.31 ha from 29,066.90 ha (16.18%) in 2001 to 29,549.20 ha in 2016. Furthermore, the dynamics of land use changes from 2001 to 2016 is depicted on Figure 4. According to GIS analysis, there were variation of land use/land cover which were changes in the increase of area of secondary

forests, settlements, rice fields, shrubs, open land and water bodies, and alteration in the decrease of area of swamps, primary forests and mixed-shrub dryland farming. Meanwhile, land cover/land use for fordryland agriculture and savanna was still the same.

Table 1: Land cover/land use changes period of 2001 and 2016 in watershed Bila

No	Type of land use/land cover	2001(ha)	2016 (ha)	Transformation(ha)
1	Swamps	5,624.08	4,713.63	(910.45)
2	Primary forests	32,734.88	30,941.49	(1,793.38)
3	Secondary forests	9,226.25	10,405.84	1,179.60
4	Settlements	499.85	1,234.36	734.51
5	Dryland agriculture	104.92	104.92	-
6	Mixed-shrub dryland farming	70,006.94	69,142.78	(864.16)
7	Savanna	3,164.19	3,164.19	-
8	Rice fields	29,066.90	29,549.20	482.31
9	Shrubs	21,329.23	21,937.67	608.45
10	Open lands	1,234.63	1,759.74	525.10
11	Water bodies	6,614.13	6,652.16	38.03
Total		179,612.95	179,612.95	

Source: Result of GIS analysis, 2016

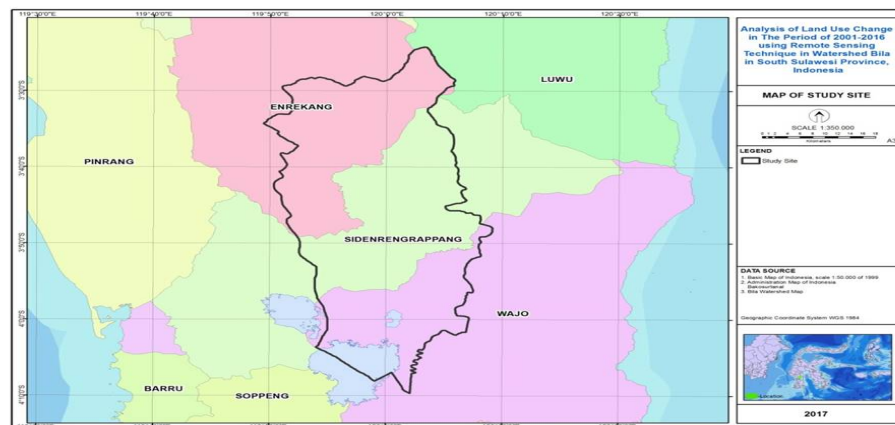


Figure 1: Study Site

In addition, Table 2 illustrated the actual condition of the forests on various type of land cover/land use in watershed Bila. The area of protected forest which was 50,339.45 ha was dominated by primary forest with an area of 28,523.89 ha (56.66%), followed by 9,694.06 ha (19.26%) of shrubs and mixed-shrub dryland farming with an area of 7,105.29 ha (14.11%). Furthermore, production forest in watershed Bila with total area of 2,388.91 ha was dominated by mixed-shrub dryland farming with an area of 2,108.72 ha (88.27%), Secondary

Dryland Forest area of 97.87 ha (4.10%) , Bushland area of 94.75 ha (3 , 97%), and rice fields area of 47.62 ha (1.99%).Moreover, limited production forests in watershed Bila with an area of 5.550,77 ha was dominated by secondary dryland forest area of 4.092,21 ha (73.72%), primary dryland forest with an area of 714.50 ha (12.87%) and mixed-shrub dryland farming area of 325.96 ha (5.87%). Moreover, Table 3. showed the result of analysis matrix of land changes for 2001-2016 period. It was presented that the area of primary dryland forests was degraded and transformed into secondary dryland forests (1701.6 ha) and shrubs (92.22 ha), whereas the coverage area of secondary dryland forests was expanding that derived from shrubs (516.23 ha), open land (5.34 ha) and clearing of primary dryland forests (1701.16 ha). As for the land use for settlements was escalating that was acquired from swamps (97.87 ha), mixed-shrub dryland farming (121.67 ha) and rice fields (514.97 ha), while the area of mixed-shrub dryland farming was decreased and altered into settlements (121.67 ha) and paddy fields (514.97 ha). Additionally, land use for rice fields was increasing which procured from mixed-shrub dryland agriculture (742.49 ha) and swamps (254.78 ha), as well as the area of shrubs that enlarged which derived from primary dryland forests (92.22 ha) and secondary dryland forests (516.23 ha). In contrast, land cover of swamps diminished and transformed into settlements (97.87 ha), paddy fields (254.78 ha), open land (519.77 ha) and water bodies (38.03 ha).

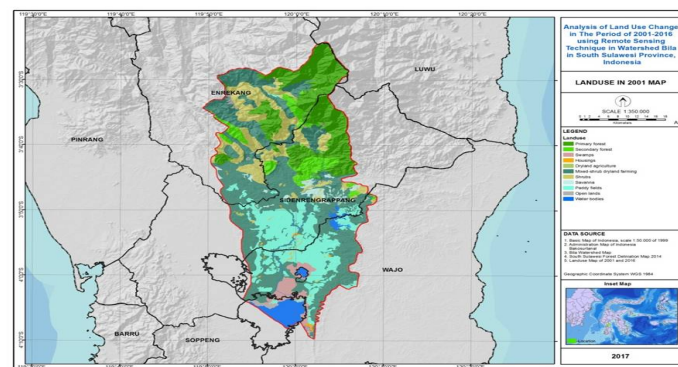


Figure 2: Map of land use/land cover in 2001

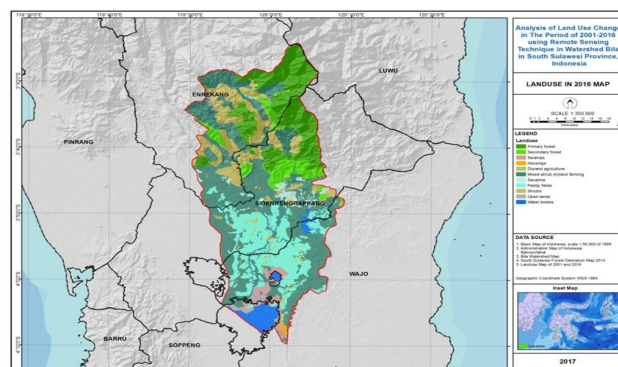


Figure 3: Map of Land use/Land cover in 2016

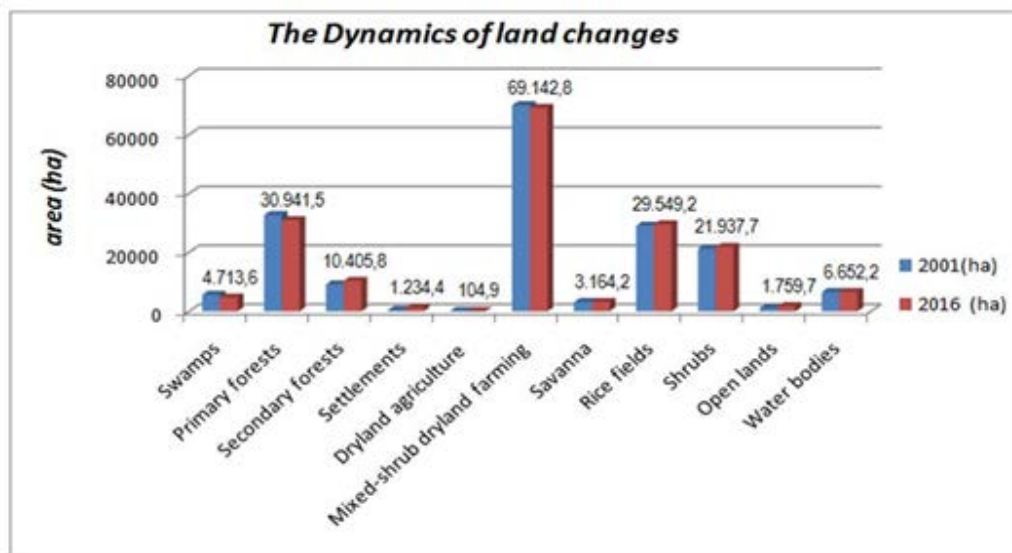


Figure 4: The dynamics of land changes

Table 2: Forest area of watershedBila on the actual type of land cover/land use

No	Zones	Land cover/land use in 2016	Area (ha)	(%)
1	Other purposes	Swamps	4,713.63	4.11
		Primary dryland forests	1,700.33	1.48
		Secondary dryland forests	1,756.44	1.53
		Settlements	1,234.30	1.08
		Dryland agriculture	104.96	0.09
		Mixed-shrub dryland farming	59,608.93	51.96
		Savanna	2,832.73	2.47
		Rice fields	29,501.58	25.71
		Shrubs	11,951.00	10.42
		Open lands	1,277.67	1.11
		Water bodies	46.51	0.04
		Total area of other purposes zone	114,728.08	100
2	Protected forests	Primary dryland forests	28,523.89	56.66
		Secondary dryland forests	4,458.92	8.86
		Mixed-shrub dryland forests	7,105.29	14.11
		Savanna	74.84	0.15
		Shrubs	9,694.06	19.26
		Open lands	482.45	0.96
		Water bodies	0.00	0.00
		Total area of protected forests zone	50,339.45	100
3	Production forests	Secondary dryland forests	97.87	4.10
		Mixed-shrub dryland forests	2,108.72	88.27
		Savanna	39.96	1.67
		Rice fields	47.62	1.99
		Shrubs	94.75	3.97
		Total area of production forests zone	2,388.91	100
4	Limited Production forests	Primary dryland forests	714.50	12.87
		Secondary dryland forests	4,092.21	73.72
		Mixed-shrub dryland forests	325.96	5.87
		Savanna	216.34	3.90

No	Zones	Land cover/land use in 2016	Area (ha)	(%)
		Shrubs	201.76	3.63
		Water bodies	0.00	0.00
	Total area of limited production forests zone		5,550.77	100
5	Water bodies	Swamps	0.02	0.00
		Secondary dryland forests	0.01	0.00
		Settlements	0.00	0.00
		Mixed-shrub dryland forests	0.08	0.00
		Savanna	0.00	0.00
		Rice fields	0.01	0.00
		Shrubs	0.03	0.00
		Open lands	0.00	0.00
		Water bodies	6,605.59	100
	Total area of water bodies zone		6,605.74	100
	Grand Total		179,612.95	

Source: Result of GIS analysis, 2016

Table 3: Matrix of land changes

Land cover of 2001	Land cover of 2016											Total
	Swamps	Primary dryland forests	Secondary dryland forests	Housings	Dryland agriculture	Mixed-shrub dryland forests	Savanna	Rice fields	Shrubs	Open lands	Water bodies	
Swamps	4713.63			97.87				254.78		519.77	38.03	5,624.08
Primary dryland forests		30941.49	1701.16						92.22			32,734.88
Secondary dryland forests			8704.68						516.23	5.34		9,226.25
Settlements				499.85								499.85
Dryland agriculture					104.92							104.92
Mixed-shrub dryland forests				121.67		69142.78		742.49				70,006.94
Savanna							3164.19					3,164.19
Rice fields				514.97				28551.93				29,066.90
Shrubs									21329.23			21,329.23
Open lands										1234.63		1,234.63
Water bodies											6614.13	6,614.13
Total	4,713.63	30,941.49	10,405.84	1,234.36	104.92	69,142.78	3,164.19	29,549.20	21,937.67	1,759.74	6,652.16	179,605.98

Source: Result of GIS analysis, 2016

4. Discussion

Based on the results of the analysis of land use changes above, some of the dynamics of land use/land cover changes were visible. For instance, primary forests, swamps and mixed-shrub dryland forests which continue to decline while the area of secondary forests is elevating. Also, the utilization of land was expanding, especially

for settlements and rice fields, which caused by the population growth that resulted in the high demand of housings and agricultural lands. The dynamics of land changes in watershed Bila, such as increase of housings, paddy fields, shrubs and open land lessen the coverage area of forests, due to the forest enroachment that altered to agricultural land and rice fields. Land use changes in watershed Bila had been proved by the result of the analysis above. The function of the areas that had been designed as protected forests, production forests and limited production forests had been converted into mixed-shrub dryland farming with the percentage of 14.11%, 88.27% and 5.87% for planting vegetables, corns and coffee consecutively of the total area of protected forests. Besides, land use changes occurred to the production forests that transformed into paddy fields with an area of 1.99% of total area of production forests. The decrease of the forest coverage area and the increase of agricultural land, shrubs, rice fields and open land generate negative impacts on the carrying capacity of watershed Bila and if the land use changes continue to occur, it would reduce its carrying capacity to the ecosystem. Rapid population growth in the area of watershed Bila, mainly who live around the forests area, will have a significant impact on the need of lands to meet the economic necessity. So that, land use changes occurred in both private land and land within the forest area that transformed into agricultural lands to attain large amount of incomes in a short time. The amount of lands is limited and non-renewable, while the population continues to grow which cause the forest areas that should be used to protect the sustainability of nature are cultivated into agricultural lands and settlements. This land use changes has brought a wide impact on our environment, both locally and globally. Local effects like forest destruction in watershed Bila that affects inhabitants who live near the watershed, and global impacts such as climate change and global warming as a result of the reduction of carbon dioxide (CO₂) absorption by vegetation, which causes the increasing of greenhouse gasses (GHG) in the atmosphere that affecting climate change [4]. Deforestation, climate change and global warming as the impact of the change of land use/land cover that ignores ecological aspects of the lands leading to the diminish of indirect benefits of the forests, which forests are the largest carbon sink and have an important role in the global carbon cycle and able to store carbon at least 10 times larger than other vegetation types like grasslands, annual crops and tundra[5]. The catchment area is a very complex ecological system consisting of various factors and components. Consequently, the management also involve diverse activities that entangle many institutions, agencies and social groups of community. Therefore, the problems become more complicated since the concern is not only technical issues of implementation, but more about organizational, planning and management issues. Land use in watershed requires integrated land use planning and balance between ecological function and economic function to maintain watershed sustainability. That land use planning is a crucial action in the utilization and usage of lands in order to obtain the best usage of lands through the achievement of efficiency, sustainability and equity and acceptance [6].

5. Conclusion and Recommendation

The results of the study presented that the class of land use/land cover was divided into 11 classes, which are swamps, primary forests, secondary forests, settlements, dryland farming, mixed-shrub dryland agriculture, savanna, rice fields, shrubs, open lands and water bodies. According to the result of GIS analysis, land changes from the year of 2001 to 2016 were varies from increase of the area to decline of the land covers. The increase of the land covers includes secondary forests, settlements, paddy fields, shrubs, open lands and water bodies whilst the decrease comprises swamps, primary forests and mixed-shrub dryland farming. In addition, the

unchanged land covers were dryland agriculture and savanna.

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